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GARBAGE REDUCTION

Report of a Subcommittee of the Committee on Refuse Collection and Disposal of the Sanitary Engineering Division

SANITARY ENGINEERING DIVISION

{Discussion open until January 1, 1955}

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THIS PAPER

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GARBAGE REDUCTION: REPORT OF A SUBCOMMITTEE OF THE COMMITTEE ON REFUSE COLLECTION AND DISPOSAL OF THE SANITARY ENGINEERING DIVISION

This report on Garbage Reduction is one of a series produced by Subcommittees of the Sanitary Engineering Division's Committee on Refuse Collection and Disposal. Other subcommittees have reported on Collection; Dumping and Land Fill; Hog Feeding; Incineration; Composting and Grinding; State Activities and Fiscal Aspects. These reports are being published as separates as they are edited. While not consecutively issued or numbered, the reports will form a series representing the final report of the Committee on Refuse Collection and Disposal.

The committee consisted of:

Henry W. Taylor, Chairman	
Norman W. Nester	Charles L. Senn
Newell L. Nussbaumer	V. M. Ehlers
Sol Pincus	Charles L. McGauhey

Members of the Subcommittee concerned are listed at the end of this and the other Subcommittee reports.

FOREWORD

In 1901, M. N. Baker made the following and now classic statement: "In no branch of m·inicipal service has so little progress been made in the United States as in the disposal of garbage. Why do such conditions exist? First, because the sanitary collection and disposal is appreciated neither by the general public nor the city officials; second, because it is seldom recognized that the problems incident to final disposal are largely engineering in character and therefore should be entrusted to engineers."

Mr. Baker's statement could be enlarged in scope by substituting "refuse" for "garbage" and adding emphasis to the need for engineering technique and administration in collection as well as in disposal methods.

Activities of this Committee on Refuse Collection and Disposal since its inception may be briefly summarized as follows:

In 1935 the Sanitary Engineering Division appointed a "Committee on Technical Aspects of Refuse Disposal" and this Committee functioned until January, 1942, during which period four reports were submitted and abstracted in Civil Engineering. The final report of this Committee stated that:

> "due to the unusual activity of members of the Committee and on account of the lack of general interest in the subject under consideration at this time, together with a feeling on the part of the Committee Members that the subject is not particularly well adapted to Committee action, it is recommended that this Committee be discontinued."

The "unusual activity" of Members of the Committee still exists. Any lack of general interest in this subject has been replaced by the pressing necessity of solving a municipal problem which places increasing demands on public officials and engineers. A new Committee was appointed in 1947 and a progress report was submitted by the Chairman, Rolph Eliassen. This progress report outlined many of the facets of this subject and the need for application of engineering technique and administration.

At the 1949 meeting of this Society, a report was submitted by the Committee on "Advancement of Sanitary Engineering," which recommended the collaboration of the personnel from other technical organizations in the activities of Committees working on projects of broad scope. The recommendation met with quick approval and the present Committee has attempted to put these recommendations into tangible form by introducing Subcommittees who operate as task groups under the leadership of the personnel of the base Committee.

A report by the Committee in January 1950 confined itself to the organization of the Committee and Subcommittees with a prospectus of objectives. A Progress Report was submitted in October 1952 and included the efforts of seven Subcommittees.

This report for 1953 may be considered as the final report of the Committee with the objectives originally stated by this Committee. The increased activity in research, in design and operation are leading to an extensive program of literature emanating from individuals, colleges, institutions and commissions and any attempt by this Committee to include all this data would be futile and a subsequent report would be largely a bibliography of this literature. In other words, present activities have extended beyond the scope of the Committee and involve a volume of current literature from various sources which are available from their original source.

This report is actually individual reports of the seven task groups acting as Subcommittees. The Chairman has considered that each group contains acknowledged experts within the scope allotted to it and has not, in general, modified or condensed the reports as submitted by these separate Subcommittees. He has also considered that it would be impracticable for the base committee as a whole to attempt to pass on or modify the work of the individual groups since the scope of these groups includes such a varied field.

The Chairman has reduced the personnel of various Subcommittees, as stated in this report, to those who have been able to devote time and submit data to their various Subcommittee Chairmen. The Chairman wishes to express his appreciation of the cooperation of the Committee and Subcommittee members.

HENRY W. TAYLOR, Chairman

A.S.C.E. Committee on
Refuse Collection and Disposal

INTRODUCTION

About sixty-five years have elapsed since the "reduction" process as a means of garbage disposal was first introduced in the United States. The period of twenty-five years from 1885 to 1910 inclusive represents the era during which the greatest number of reduction plants were constructed. For the most part these plants were financed, installed, and operated by private contractors. Available technical literature in the field of municipal sanitation describes at length the vicissitudes of the various reduction systems in use during that time. Therefore, it is deemed sufficient to outline briefly and as a matter of historical interest only, the earlier installations of the processes of reduction.

Broadly speaking, all processes of reduction are confined to two classifications or combinations thereof; (a) the drying method and (b) the cooking method. Both methods may or may not be followed by degreasing, redrying, grinding and screening operations.

The Merz process is typical of the drying method and was introduced at Buffalo in 1886. The installation there was followed by other plants at Chicago, Columbus, Milwaukee, Paterson, Saint Paul and Saint Louis.

The Arnold process is representative of the cooking method. A plant of this type was constructed near Boston in 1895 and other installations subsequently followed at Baltimore, New York City, Philadelphia, Pittsburgh, Rochester and elsewhere.

The CHAMBERLAIN process is also a cooking method which originated at Detroit in 1898. Plants of this type were afterwards built at Cleveland, Cincinnati, Indianapolis, Schenectady and Washington.

Other processes, such as the HOLTHAUS which was installed at Bridgeport, New Bedford, and Syracuse; the SIMONIN at Cincinnati, New Orleans and Providence; the WISELOGEL at Jacksonville and Vincennes; and the WHEELRIGHT at New Bedford, were also various modifications of the early cooking methods.

Since the year 1910, the reduction plants constructed have been few.

The straight and modified COBWELL SYSTEMS that were installed at Los Angeles; Lower Staten Island- New York, New Bedford, Syracuse, Rochester and Schenectady; and the MORRISON SYSTEMS at Indianapolis, Dayton and Lorain are representative. Several of these plants have ceased operation and the disposal of garbage is now carried out by other methods.

In the year 1918 there were twenty-four reduction plants in operation in seventy-five cities, of the United States, with ninety thousand population and upwards. This number was reduced to seven plants in 1942 and in 1952 to two at Syracuse, N. Y. and Rochester, N. Y. Incineration has superseded reduction at Baltimore, Bridgeport, Cincinnati, Columbus, Cleveland, Detroit, Pittsburgh and Schenectady. It is impossible to forecast the future status of the reduction processes now installed and in use at Indianapolis, Rochester and Syracuse. But it is not unreasonable to predict that within the period of the next ten or more years, disposal of garbage by the older reduction methods will have become a matter of history.

Merz Process

Probably the outstanding example of the Merz process was the plant in service at Chicago up until its abandonment early in 1928.

At this plant, the garbage was dumped into a pit, having a capacity of 600 tons and thence it was conveyed to a set of crushers or disintegrators. The purpose of crushing the garbage was to make the material uniform in size and better enable the heat and solvent to penetrate the mass.

After the garbage was crushed, the material was conveyed first to six primary driers of the direct fire type. These driers were steel cylinders, forty feet in length and fifty-six inches in diameter and rotated at a speed of nine revolutions per minute. They were fired with fuel oil which produced a temperature of approximately two thousand degrees Fahrenheit at the feeding end and five hundred degrees at the exit. The primary driers reduced the moisture in the garbage from sixty-five percent to thirty percent.

The material, after passing the primary driers, was conveyed to two secondary driers which were of the indirect fire type. These driers were also steel cylinders seventy feet long and seven feet in diameter. The secondary units further reduced the moisture from thirty percent to ten percent at which point it was suitable for percolation with naphtha solvent.

The dried garbage was then conveyed to an extraction building where there were installed seven percolators with a capacity of ten tons each and three percolators with a capacity of fifteen tons each. After loading with dried garbage, the solvent was introduced in the percolators and the material washed for a period of about one and one half hours or until it was free of the grease content. The mixture of grease and naphtha was drained from the percolators and pumped to evaporators where by means of steam heat the moisture and solvent were driven off as vapors.

These vapors were condensed and the water and naphtha collected in separating tanks whence the solvent was returned to the storage tanks for re-use. The grease was pumped to settling tanks and after a period of settling was drawn off and transferred to large storage tanks ready for shipment.

In the extracting process, the tankage again attained a moisture content of twenty-five percent and therefore had to be re-dried to ten percent moisture content and also screened before it was suitable as a filler for fertilizers.

This plant produced approximately six million pounds of grease and five thousand tons of tankage (fertilizer filler) annually from about one hundred tons of garbage.

Arnold Process

The Arnold process is best exemplified by the plant still in service at Philadelphia after more than thirty-five years of operation. This process differs from the Merz process essentially in that the garbage, after picking over for the removal of glass, tin cans, crockery, etc., is charged into large vertical steel tanks which are called "digesters." The digesters generally have a capacity of eight to ten tons. After filling

they are sealed, a small amount of water is introduced, and then live steam at about eighty pounds gauge pressure turned therein. The mass is cooked under pressure until disintegrated and the grease released.

The cooked garbage is discharged from the digesters to presses which may be of the roller type or the basket and similar types, that are actuated by hydraulic rams. The mixture of grease and water that has been expressed is run to baffled settling basins wherein the grease is skimmed from the surface of the water and thence transferred to settling tanks for further removal of moisture.

The pressed material is dried, percolated, re-dried, and screened as outlined under the Merz process.

Chamberlain Process

The one plant representative of the Chamberlain process in operation today is located at Washington, D. C.

This process does not differ greatly from the Arnold process. The difference is that after cooking the garbage in the digesters, pressing of the mass is accomplished by introducing live steam under pressure into the top of the tank and allowing the mixture of grease and water to pass out at the bottom through perforated plates or pipes whence it is conducted to the settling tanks or basins.

The Cobwell Process

The Cobwell reducer consists of a flat cylindrical steel shell about ten feet in diameter and four feet high. A steam jacket is provided under the bottom and around the lower two-thirds of the circumference of the shell. A set of cast steel plow arms, mounted on a vertical shaft with top and bottom bearings at the center of the shell, are rotated close to the inner bottom of the reducer. These arms slide under the mass of garbage, imparting to it an undulatory motion.

The mechanism for driving the plow arm shaft at ten revolutions per minute is mounted on the flat top of the reducer. A charging door, a peep glass for observing the action within the reducer; and outlets for water and solvent vapors are provided on this same top. The discharge door is set into the reducer shell at the low point of its circumference and several perforated drain-boxes project upward into the bottom of the reducer. These boxes serve not only as outlets for removing the grease extracted from the garbage but also as inlets for the volatile solvent and live steam introduced at various periods in the reduction cycle. Each reducer is equipped with an individual steam trap and the necessary steam, solvent, and drain valves, drain sightglass and piping, and is supported on a heavy structural iron frame.

In other respects the Cobwell system does not differ greatly from that of the older systems. The usual types of conveying equipment for handling the green garbage and the rough and finished tankage are provided.

There are electric prime movers and power transmission equipment; surface condensers and condensate, solvent, and grease pumps, and steam evaporators, and the various separator and storage tanks for

water, solvent and grease. There is also crushing and screening machinery for converting the rough tankage into a granular filler for fertilizers.

The straight Cobwell process in itself is carried on to its conclusion as a single continuous operation in the closed unit. Furthermore, after the reducer has been charged the several operations performed in the older processes and involving the use of hand labor and the movement of the garbage to and from different kinds of equipment are not required.

The complete reduction cycle consumes about twenty-one hours of which about sixteen hours is required for dehydration, three hours for washing, one hour for drying, and one hour for loading, dumping and miscellaneous.

The most interesting feature of the Cobwell process is that of the temperature produced during the reduction of the garbage mass. Submerged in a bath of petroleum naphtha which acts not only as a heat transfer medium but also as a preventive of bacterial growth and hydrolysis, the garbage gives up its moisture content and disintegrates at a temperature of about two hundred degrees Fahrenheit. The vaporization of the water and solvent by the jacket heat at a steam pressure of ninety pounds is accomplished at this low temperature and therein lies one of the reasons for the non-production of obnoxious odors that are common to the older systems.

The Cobwell plant at Rochester was constructed in 1920-1921. The reducer building houses forty Cobwell units with a nominal capacity of five tons each. At times, the plant has treated upwards of two hundred twenty-five tons per day. Other representative installations of the straight Cobwell system were the plants of the Metropolitan By-Products Corporation, Lower Staten Island, Borough of Richmond, New York, and of the Pacific Reduction Company at Los Angeles, California. The first mentioned plant was constructed to supplant the older Barren Island plant and contained one hundred ninety nine Cobwell units with a total capacity of more than one thousand tons per day. However, for several reasons, its operation was limited to about fifteen months in 1917-1918. The Cobwell plant at Los Angeles was operated during a period of about six years from 1915-21. In the earlier years, its operation was successful in almost every respect. But the aftermath of the First World War brought a rapid decline in prices of by-products that coupled with an unsatisfactory proposal at the same time from the City of Los Angeles, caused the abandonment of the plant.

The Cobwell-Merz or Modified Cobwell Process

The modified Cobwell process differs from the straight Cobwell process only in the initial steps wherein the garbage is dehydrated by the means of direct heat driers that have been previously described under the heading of the Merz process. The moisture content is reduced about fifty percent by the direct heat and the material conveyed to the Cobwell units to undergo final dehydration, degreasing, redrying. The dehydration of the garbage by means of direct heat is much faster and more economical than by jacket steam as in the straight Cobwell process. However, the material must be rehandled and with the high temperature,

there is always danger of carbonization and production of obnoxious odors. The quality of the tankage is inferior to that produced by the straight Cobwell system.

The modified Cobwell plant at Syracuse stands today as the only one of its type in service. It was constructed in 1920 for, and its operation begun by, the municipality. After a few months, the operation was transferred to the present contractor, the Cobwell Reduction Company Inc. which is now carrying out its fourth five year contract with the City of Syracuse. Originally, the plant contained twelve Cobwell units with a nominal capacity of sixty tons per day. In 1923, primary driers were added and the capacity increased to about eighty-five tons per day.

The City of Schenectady installed a modified Cobwell system with a capacity of ninety tons per day in 1925. The plant contained two primary driers and four Cobwell units. Operation of this plant was discontinued about ten years ago. The operation of the modified Cobwell system at the plant of the New Bedford Extractor Company was abandoned in 1923. It was at this plant that much of the early pioneering work in the perfection of the Cobwell system was carried out.

The Morrison Process

In the Morrison process, of which the Indianapolis plant is representative, the garbage is conveyed from the receiving pit to an elevated point and discharged through gravity chutes to any one of thirty two digesters. The digesters are of the vertical, steam jacketed type and provided with heavy agitators that are driven from below the unit and pipe connections for live steam, decantation, and venting of condensible vapors. Each digester has a capacity of three and one half tons and two charges can be treated in twenty-four hours.

The charge of garbage is mixed with water from a previous run and digested at eighty pounds guage steam pressure for a period of two hours after which the pressure is vented through a jet condenser and the cooked mass permitted to settle. After settling, the supernatant tank liquor is drawn off to a sump, whence it passes to a grease separator. The water is drawn off from the separator and treated for recovery of so-called "stick" liquor.

Solids that remain in the digester are dried by means of steam jacket heat with agitation and fifteen inch vacuum, this operation requiring about six and one half hours.

The dried rough tankage is then discharged from the digester and conveyed to a separation and degreasing building. At this location first and second-grade animal feed and fertilizer filler may be produced as desired.

The first-grade feed is not degreased but instead is removed from the tankage by mechanical separation, employing air suction and cyclones. The second-grade feed and fertilizer material is degreased in vertical percolators, utilizing naphtha solvent with five to ten washes of fifteen to twenty minutes duration. The grease is recovered by distillation, the naphtha vapors being condensed and the naphtha solvent returned to storage for further use. The tankage is dried by steam jacket heat before discharge from the percolators and is then passed to the mechanical

separators. The fertilizer grade of tankage is subjected to magnetic separation and grinding. First-grade feed contains the concentrated "stick" liquor whereas the second-grade feed contains no "stick" and only a small percentage of grease.

The Morrison process was installed and its operation begun at Indianapolis in 1927 under the direction of the Board of Sanitary Commissioners. Operation was discontinued early in 1935, after about eight years of service because the walls of the digesters were so weakened by corrosion that their continued operation became dangerous. However, replacements were then made and operation resumed. Other installations of the Morrison process were made at Dayton and Lorain. The Dayton plant was constructed in 1924, the nominal capacity being one hundred tons per day. The Lorain plant was installed in 1926 and was rated at forty tons per day. The first mentioned plant was installed for, and operated by the Municipality. The Lorain plant was owned and operated by the Lorain Reduction Co. Both of these plants ceased operation several years ago.

Combination of Incineration & Reduction Processes at Philadelphia

A combination of existing processes was installed at the Harrowgate incinerator in northeast Philadelphia. The original installation that was made in 1924 consists of four Sterling type destructor units with a capacity of two hundred eighty tons in twenty-four hours. During July 1935, an addition to the original plant was constructed that consists of twelve Arnold type digesters with a nominal capacity of eight tons each. After a charge is cooked, utilizing steam which is generated by waste heat from one of the furnaces, it is dewatered and degreased in a horizontal hydraulic press. The tankage is conveyed to the furnaces for fuel purposes. The pressed liquid portion or grease and water combined, is pumped to settling tanks where the grease is skimmed off and held for marketing. It was stated that the use of the combined processes at this plant would make a substantial saving in the cost of fuel (coal) and labor and prevent the occurance of obnoxious odors, either during operation or from storage of garbage due to the lack of sufficient combustible material for straight incineration purposes.

Changes and Modifications

Over the period of sixty years, two or more processes of reduction were installed in several of the cities herein before mentioned; utilized for a period of years; and then abandoned. Even those processes which have served certain cities continuously for a period of thirty or more years have seen many changes and modifications. The existing reduction plant at Philadelphia is called the improved Arnold type; the earlier Arnold type of plant at Rochester was named the Beaston process; and the installation at Cleveland was termed the Chamberlain-Edson-Edgerton system. The Cobwell systems that were installed at Schenectady and Syracuse, were changed by incorporation in part of the older Merz system. It has remained for the straight Cobwell system that is

in service at Rochester to have experienced more than thirty-one years of continuous operation without any basic modifications of the original installation.

Comparison of Various Processes of Reduction

A comparison of the various processes of reduction, particularly from the "odor production" and economic standpoint is of interest.

Referring to Fig. 1, it is noted that the older processes of the Arnold and Chamberlain type involve not only several operations but also, the use of various kinds of equipment; i.e. digesters, presses, percolators, driers, etc. Furthermore the garbage must be rehandled either by hand labor or by means of conveying machinery as each step progresses. While the labor is in general of a cheaper grade, nevertheless, a large quantity is required. In addition the exposure of the garbage to atmosphere at each step produces considerable odor. Certain steps may require redrying the material which operation is also productive of odor. The cooking of the garbage in digesters at high steam temperatures causes so-called "digestion" odors which are most difficult to control and expensive to destroy. The same condition, exists in the use of direct-fired driers where the vapors at the exit end of the units after attempts at scrubbing and condensing must be dispersed to the atmosphere and to the sewer. The odors may carry for long distances and depreciate property values for a radius of several miles. At one time, it was believed that treatment of the vapors by the Henderson-Haggard (chlorine) method might solve the problem. However, experience in a short time proved there was very little if any chemical action but rather only a mechanical mixing of vapors and chlorine. While the chlorine gas, if employed in sufficient quantity, will mask the odors in close proximity to the source of their production, a separation occurs at a distance. Earlier experiments had demonstrated that the odors can be effectively destroyed by a temperature of eighteen hundred degrees Fahrenheit or more but the quantity of heat required is enormous and much too expensive for practical consideration. As a result, plants in which the older types of processes are employed must be located a considerable distance from the municipality and in a sparsely settled community. Such location results in a higher cost of transportation. In the larger cities, the use of transfer stations and special railroad cars is necessary. As the years have passed and higher standards of sanitation have become a necessity the objectionable odors of the older systems of reduction are one of the major factors in forcing their abandonment. Corrosion and erosion that cause a relatively high depreciation of equipment have also been a contributing factor. Thus the production of objectionable odors and the high cost of labor, steam and maintenance for the older types of reduction processes coupled with the reduced price paid for low grades of grease and organic ammoniates, has produced a marked decline in continuation of these processes in recent years.

It is a fact that the straight Cobwell system of reduction does not produce the objectionable odors of the older processes in that a very low temperature of dehydration is employed and the complete cycle of reduction is carried out in the Cobwell unit. However, the cost of labor,

steam, solvent, and maintenance equals or may even exceed similar costs for the older processes. Therefore, while from a sanitary standpoint the straight Cobwell system is entirely satisfactory, the revenues from the scale of by-products should be sufficient to offset the larger portion of the normal cost of operation, if financial success is to be attained.

Garbage Tankage as A Feed

Considerable experimentation has been carried out in recent years, utilizing garbage tankage directly or in a mixture as a hog and poultry feed. The material has been produced by the straight Cobwell system as employed at Rochester; the Morrison-McCullough system at Indianapolis; and experimental Carewe-Moreton system at Los Angeles.

Inasmuch as the first mentioned system employs extraction with a petroleum solvent, it was found that certain essential vitamins were removed and had to be replaced. Satisfactory results could only be obtained by feeding a mixture of various grains and tankage in the proportion of about thirty five percent of tankage. The decline in the prices of feed during the year of 1931 concluded the feeding experiments at Rochester and the sale of Cobwell tankage for use in manufactured feed elsewhere. Neither the experiments nor the sales for this purpose have been resumed.

At Indianapolis, the installation of the Morrison-McCullough system was predicated on the ready sale of the larger portion of the tankage for feeding purposes at a price of about thirty dollars per ton. In theory, this revenue plus that obtained from sale of grease and the portion of the tankage that was only suitable for fertilizer filler indicated an excellent profit. From available records, it appears that about twenty-five percent of the tankage which was produced over the seven year period of 1928-34 was converted to animal feed and the other seventy five percent sold for fertilizer purposes. Therefore, with the decline in the normal sale price of grease and tankage during the past ten years it is doubtful whether or not the Indianapolis plant has actually shown a profit during its operation to date.

Seventeen years ago, Messers, Carewe and Moreton developed the Biltmore Conservation system at Los Angeles. This process utilized dry rendering equipment similar to that employed in packing houses. At a certain point in the process, chemicals were added and the cooking operation was continued until a dry feed mixture was produced. An experimental unit was operated at the Syracuse "Cobwell" plant for a period of several months. About the same time, a large plant was installed at Dallas, Texas by a private contractor with the idea of processing the municipal garbage. Subsequently, the contract with the City was not realized and the plant was abandoned. However, experience here and there up to date does not detract from the fact that there may be potential possibilities for profit in the production of animal feed from garbage tankage with normal market conditions.

As indicated in the above report there has been a decrease in the number of operating garbage reduction plants. This has been caused largely by the low prices for grease in certain years and the wide

fluctuations over a period of time. The Cherry Hill plant in the District of Columbia was abandoned in September 1949. The principal reason for the abandonment of the reduction method was the failure of the market price for grease to keep pace with the ever mounting costs of maintenance and operation, the Superintendent of Sanitation reports. Furthermore the future price trend outlook did not appear too bright due to the competition from detergents, the decrease in per capita production of garbage and the loss of quality resulting from less wastage of meats and fish, the principal grease producing items, and the trend toward the use of garbage grinders in this area.

Tables I and II comprise a report on grease and tankage revenue at the Rochester plant which illustrates in more detail the effect on their revenues.

Fig. 2 shows costs of operation of the Cobwell System at Rochester. Table III shows costs of garbage reduction at Cleveland, Ohio.

Respectfully submitted,

Newell L. Nussbaumer, Chairman
John V. Lewis

Subcommittee on Garbage Reduction of the
Committee on Refuse Collection and Disposal

Table I

CITY OF ROCHESTER, NEW YORK

SALE PRICE OF GARBAGE GREASE

DOLLARS PER CWT. - F.O.B. BUYER'S TANKS AT PLANT

Year	1st. Quar.	2nd. Quar.	3rd. Quar.	4th. Quar.	Net Yr. Avg.	Net Revenue
1946	7.00	7.00	7.00	7.00	6.77	$111,080.
1947	14.00	21.50	7.07	12.40	13.98	189,713.
1948	14.78	11.21	11.17	4.875	10.09	112,528.
1949	3.75	2.60	1.50	1.50	2.35	32,934.
1950	1.25	1.00	1.75	5.60	2.28	33,468.

NOTE: Net yearly average price includes deductions for MIU content of grease and 1% brokerage fees if paid. During the year 1946, OPA ceiling price prevailed.

Table II

NET REVENUES - GARBAGE REDUCTION PLANT

Year	Grease	Tankage	Total	Tons-Garbage	Revenue Per Ton
1946	$111,030.	$31,563.	$142,643.	53,060	$4.30
1947	189,713.	42,360.	232,073.	32,725	7.10
1948	112,528.	38,292.	150,820.	32,275	4.65
1949	32,934.	32,163.	65,097.	32,145	2.00
1950	33,468.	53,008.(x)	86,467.	30,700	2.82
1951	94,168.	31,052.	125,220.	27,300	4.60

NOTE: Tankage sold for $12.00 per ton, F.O.B. Rochester, for the first time since operation of plant began in October, 1921.
Price for the year of 1951 is $7.25 per ton. The sale price of tankage has varied from $5.50 to $12.00 per ton, F.O.B. cars, Rochester, New York.

Table III

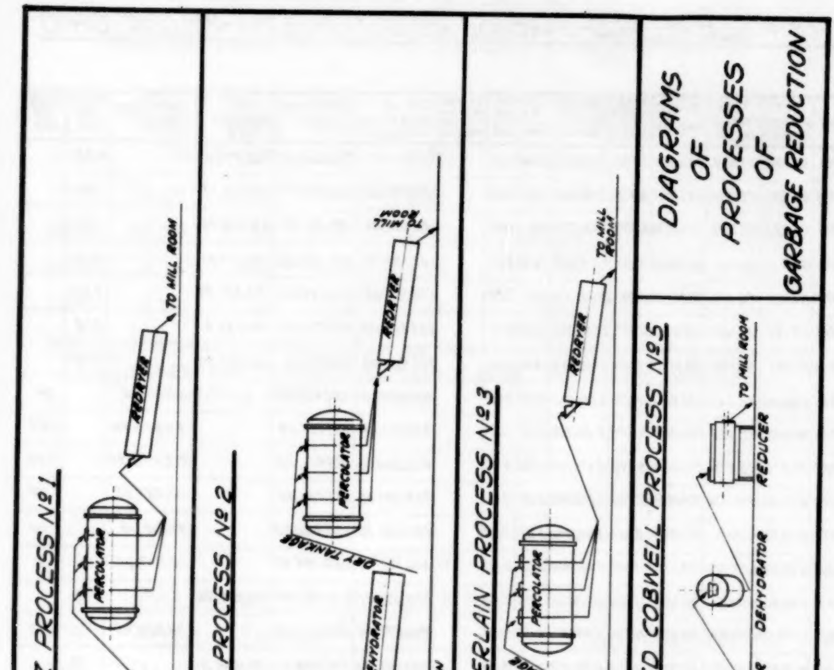
CITY OF CLEVELAND—GARBAGE REDUCTION PLANT
WILLOW, OHIO

CITY OF CLEVELAND-GARBAGE REDUCTION PLANT-WILLOW, OHIO

YEAR	TONS GARBAGE COLLECTED	TONS GARBAGE REDUCED	PAY-ROLL REDUCTION	TONS TANKAGE PRODUCED	POUNDS GREASE PRODUCED	GREASE PRICES		TANKAGE PRICE TON		COST OF REDUCTION YEAR	EARNINGS YEAR	NET PROFIT YEAR	NET LOSS YEAR	PROFIT PER TON	LOSS PER TON
						HIGH	LOW	HIGH	LOW						
1913	52,384	52,384	$54,163.31	5,098	3,238,116	4.04	4.01			$101,511.27	$148,010.85	$46,499.58		$.88	
1914	55,730	55,730	73,770.21	5,878	3,290,105	4.60	4.04			128,490.60	184,202.77	55,712.17		.99	
1915	62,357	62,357	77,167.54	6,879	3,731,770	4.41	4.26			135,457.26	198,821.72	63,364.46		1.01	
1916	60,717	60,717	82,230.33	7,037	3,819,325	7.28	4.41			142,157.73	279,355.53	137,197.80		2.25	
1917	56,121	56,121	93,258.70	6,341	3,071,092	8.01	7.28			178,727.08	313,549.07	134,821.99		2.40	
1918	57,754	57,754	114,145.63	6,329	2,726,786	13.50	8.01			254,058.06	378,294.57	124,233.51		2.15	
1919	60,932	60,932	134,345.79	7,093	3,116,797	13.50	5.00			224,703.43	354,771.02	130,067.59		2.13	
1920	68,645	68,645	272,954.01	7,922	3,490,337	10.40	3.00			353,959.07	337,477.42		16,481.65		.24
1921	92,385	92,385	246,755.51	11,024	5,401,320	3.19	1.50			378,951.14	241,101.19		137,849.95		1.49
1922	96,275	96,275	277,005.96	8,794	5,070,886	5.26	3.56			418,603.36	198,911.02		219,692.34		2.28
1923	*111,126	*101,734	224,658.46	7,733	5,258,859	5.05	5.01			383,589.33	283,051.46		100,557.87		.90
1924	*123,775	*108,011	191,232.26	8,362	3,641,798	5.32	5.08			293,442.52	235,930.38		57,512.14		.46
1925	*143,575	*119,966	193,370.76	11,984	4,341,160	6.50	6.50			300,111.76	283,194.42		16,917.34		.11
1926	*157,551	*132,941	186,716.20	12,062	4,411,440	7.05	6.50			298,575.94	319,235.40	20,759.46		.13	
1927	*146,110	*123,932	188,242.42	12,950	4,663,915	6.50	4.695			298,577.34	264,289.05		34,288.29		.23
1928	*131,837	*109,378	181,798.92	13,720	4,401,370	6.325	5.85			282,009.63	298,998.31	16,988.31		.12	
1929	*128,689	*102,270	183,313.66	14,560	4,277,700	6.875	5.75			279,271.44	306,538.25	27,266.81		.21	
1930	115,260	94,000	187,767.50	12,509	4,020,500	5.35	3.01			281,983.42	203,922.77		78,060.65		.67
1931	116,469	91,523	188,535.32	12,741	4,019,755	2.16	1.875			266,917.84	138,123.55		128,794.29		1.10
1932	102,131	80,014	158,560.77	11,403	3,740,245	1.5	.0625			225,198.43	70,068.85		155,129.58		
1933	88,831	65,188	121,849.07	9,182	3,005,909	2.165	.0675			169,003.38	67,659.02		101,344.36		

* PROBABLY INACCURATE.

NOTE: THE EXCESSIVE COSTS IN 1922 AND 1923 WERE DUE TO THE STRIKE OF GARBAGE WORKERS.


MERZ PROCESS No 1
CRUSHER
DEHYDRATOR
PERCOLATOR
REDRYER
TO MILL ROOM
ARNOLD PROCESS No 2
GREEN GARBAGE
VENT
DIGESTER
DIGESTER
RECEIVING TANK
PRESS
LIQUOR RUNOFF
DRAIN
PRESSED TANKAGE
DEHYDRATOR
DRY TANKAGE
PERCOLATOR
REDRYER
TO MILL ROOM
CHAMBERLAIN PROCESS No 3
GREEN GARBAGE
VENT
DIGESTER
DIGESTER
DEHYDRATOR
DRY TANKAGE
PERCOLATOR
REDRYER
TO MILL ROOM
COBWELL PROCESS No 4
GREEN GARBAGE
TO MILL ROOM
REDUCER
MODIFIED COBWELL PROCESS No 5
CRUSHER
DEHYDRATOR
REDUCER
TO MILL ROOM
DIAGRAMS OF PROCESSES OF GARBAGE REDUCTION
Fig. 1

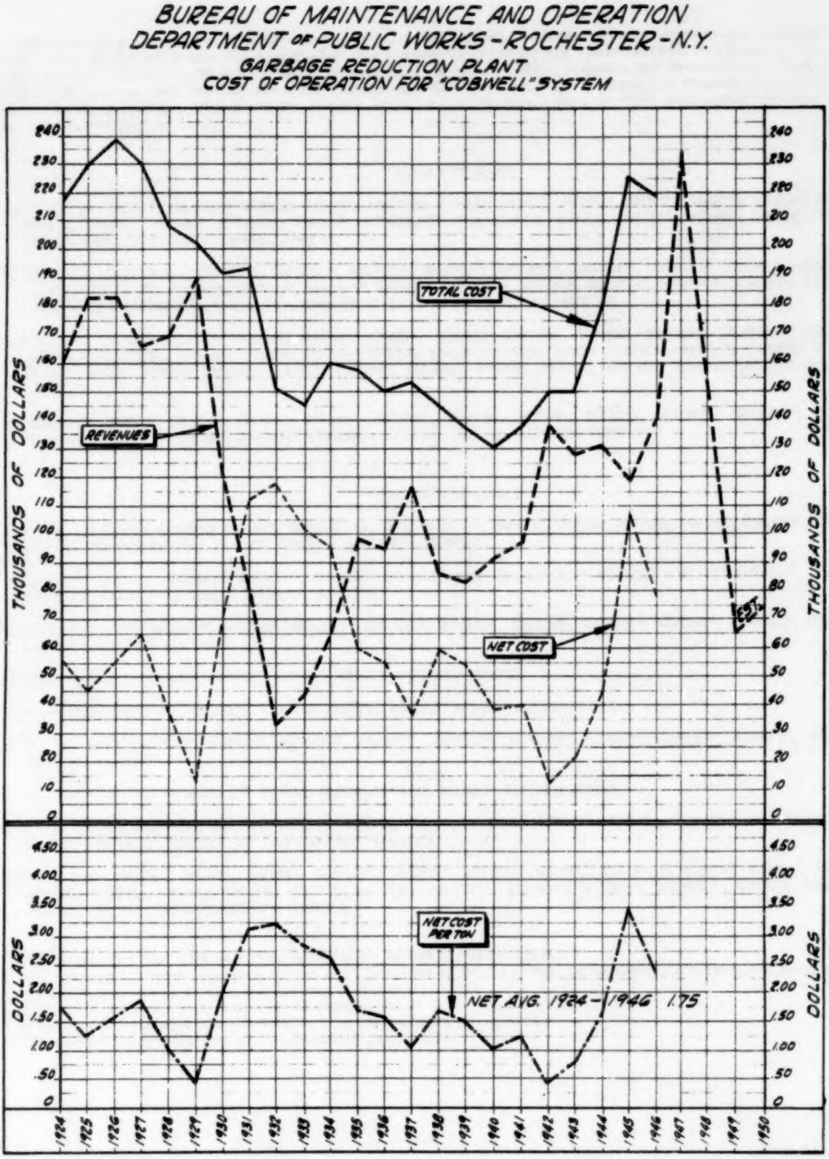

BUREAU OF MAINTENANCE AND OPERATION
DEPARTMENT of PUBLIC WORKS - ROCHESTER - N.Y.
GARBAGE REDUCTION PLANT
COST OF OPERATION FOR "COBWELL" SYSTEM
THOUSANDS OF DOLLARS
TOTAL COST
REVENUES
NET COST
NET COST PER TON
NET AVG. 1924 - 1946 1.75
DOLLARS
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950

Fig. 2

PROCEEDINGS-SEPARATES

The technical papers published in the past year are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

VOLUME 79 (1953)

SEPTEMBER: 260(AT), 261(EM), 262(SM), 263(ST), 264(WW), 265(ST), 266(ST), 267(SA), 268(CO), 269(CO), 270(CO), 271(SU), 272(SA), 273(PO), 274(HY), 275(WW), 276(HW), 277(SU), 278(SU), 279(SA), 280(IR), 281(EM), 282(SU), 283(SA), 284(SU), 285(CP), 286(EM), 287(EM), 288(SA), 289(CO).

OCTOBER:[b] 290(all Divs), 291(ST)[a], 292(EM)[a], 293(ST)[a], 294(PO)[a], 295(HY)[a], 296(EM)[a], 297(HY)[a], 298(ST)[a], 299(EM)[a], 300(EM)[a], 301(SA)[a], 302(SA)[a], 303(SA)[a], 304(CO)[a], 305(SU)[a], 306(ST)[a], 307(SA)[a], 308(PO)[a], 309(SA)[a], 310(SA)[a], 311(SM)[a], 312(SA)[a], 313(ST)[a], 314(SA)[a], 315(SM)[a], 316(AT), 317(AT), 318(WW), 319(IR), 320(HW).

NOVEMBER: 321(ST), 322(ST), 323(SM), 324(SM), 325(SM), 326(SM), 327(SM), 328(SM), 329(HW), 330(EM)[a], 331(EM)[a], 332(EM)[a], 333(EM)[c], 334(EM), 335(SA), 336(SA), 337(SA), 338(SA), 339(SA), 340(SA), 341(SA), 342(CO), 343(ST), 344(ST), 345(ST), 346(IR), 347(IR), 348(CO), 349(ST), 350(HW), 351(HW), 352(SA), 353(SU), 354(HY), 355(PO), 356(CO), 357(HW), 358(HY).

DECEMBER: 359(AT), 360(SM), 361(HY), 362(HY), 363(SM), 364(HY), 365(HY), 366(HY), 367(SU)[c], 368(WW)[c], 369(IR), 370(AT)[c], 371(SM)[c], 372(CO)[c], 373(ST)[c], 374(EM)[c], 375(EM), 376(EM), 377(SA)[c], 378(PO)[c].

VOLUME 80 (1954)

JANUARY: 379(SM)[c], 380(HY), 381(HY), 382(HY), 383(HY), 384(HY)[c], 385(SM), 386(SM), 387(EM), 388(SA), 389(SU)[c], 390(HY), 391(IR)[c], 392(SA), 393(SU), 394(AT), 395(SA)[c], 396(EM)[c], 397(ST)[c].

FEBRUARY: 398(IR)[d], 399(SA)[d], 400(CO)[d], 401(SM)[c], 402(AT)[d], 403(AT)[d], 404(IR)[d], 405(PO)[d], 406(AT)[d], 407(SU)[d], 408(SU)[d], 409(WW)[d], 410(AT)[d], 411(SA)[d], 412(PO)[d], 413(HY)[d].

MARCH: 414(WW)[d], 415(SU)[d], 416(SM)[d], 417(SM)[d], 418(AT)[d], 419(SA)[d], 420(SA)[d], 421(AT)[d], 422(SA)[d], 423(CP)[d], 424(AT)[d], 425(SM)[d], 426(IR)[d], 427(WW)[d].

APRIL: 428(HY)[c], 429(EM)[c], 430(ST), 431(HY), 432(HY), 433(HY), 434(ST).

MAY: 435(SM), 436(CP)[c], 437(HY)[c], 438(HY), 439(HY), 440(ST), 441(ST), 442(SA), 443(SA).

JUNE: 444(SM)[e], 445(SM)[e], 446(ST)[e], 447(ST)[e], 448(ST)[e], 449(ST)[e], 450(ST)[e], 451(ST)[e], 452(SA)[e], 453(SA)[e], 454(SA)[e], 455(SA)[e], 456(SM)[e].

JULY: 457(AT), 458(AT), 459(AT)[c], 460(IR), 461(IR), 462(IR), 463(IR)[c], 464(PO), 465(PO)[c].

AUGUST: 466(HY), 467(HY), 468(ST), 469(ST), 470(ST), 471(SA), 472(SA), 473(SA), 474(SA), 475(SM), 476(SM), 477(SM), 478(SM)[c], 479(HY)[c], 480(ST)[c], 481(SA)[c], 482(HY), 483(HY).

SEPTEMBER: 484(ST), 485(ST), 486(ST), 487(CP)[c], 488(ST)[c], 489(HY), 490(HY), 491(HY)[c], 492(SA), 493(SA), 494(SA), 495(SA), 496(SA), 497(SA), 498(SA), 499(HW), 500(HW), 501(HW)[c], 502(WW), 503(WW), 504(WW)[c], 505(CO), 506(CO)[c], 507(CP), 508(CP), 509(CP), 510(CP), 511(CP).

a. Presented at the New York (N.Y.) Convention of the Society in October, 1953.
b. Beginning with "Proceedings-Separate No. 290," published in October, 1953, an automatic distribution of papers was inaugurated, as outlined in "Civil Engineering," June, 1953, page 66.
c. Discussion of several papers, grouped by Divisions.
d. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.
e. Presented at the Atlantic City (N.J.) Convention in June, 1954.